TENNESSEE DEPARTMENT OF EDUCATION
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Engineering Design I

Primary Career Cluster:	Science, Technology, Engineering, and Mathematics (STEM)
Consultant:	Bethany King Wilkes, (615) 532-2844, Bethany.Wilkes@tn.gov
Course Code:	TBD
Prerequisite(s):	*Principles of Engineering & Technology* (recommended); *Algebra I*; and *Physical Science* or *Biology*
Co-requisite:	*Geometry*
Credit:	1
Grade Level:	10
Graduation Requirement:	This course satisfies one of three credits required for an elective focus when taken in conjunction with other STEM courses.
Programs of Study and Sequence:	This is the second course in the *Engineering* program of study.
Necessary Equipment:	Refer to the equipment list found on the STEM website linked below.
Aligned Student Organization(s):	Skills USA: http://www.tnskillsusa.com Brandon Hudson, (615) 532-2804, Brandon.Hudson@tn.gov Technology Student Association (TSA): http://www.tntsa.org Amanda Hodges, (615) 532-6270, Amanda.Hodges@tn.gov
Coordinating Work-Based Learning:	If a teacher has completed work-based learning training, appropriate student placement can be offered. To learn more, please visit http://www.tn.gov/education/cte/wb/.
Available Student Industry Certifications:	None
Dual Credit or Dual Enrollment Opportunities:	There are no known dual credit/dual enrollment opportunities for this course. If interested in developing, reach out to a local postsecondary institution to establish an articulation agreement.
Teacher Endorsement(s):	013, 014, 015, 016, 017, 018, 047, 070, 078, 081, 210, 211, 212, 213, 214, 413, 414, 415, 416, 417, 418, 230, 231, 232, 233, 470, 477, 519, 531, 595, 596
Required Teacher Certifications/Training:	Teachers who have never taught this course must attend training provided by the Department of Education.
Teacher Resources:	http://www.tn.gov/education/cte/doc/STEMResourceList.pdf

Course Description

Engineering Design I is a fundamental course in the STEM cluster for students interested in developing their skills in preparation for careers in engineering and technology. The course covers essential knowledge, skills, and concepts required for postsecondary engineering and technology fields of study. Upon completion of this course, proficient students are able to describe various engineering disciplines, as well as admissions requirements for postsecondary engineering and engineering technology programs in Tennessee. They will also be able to identify simple and complex machines; calculate various ratios related to mechanisms; explain fundamental concepts related to energy; understand Ohm's Law; follow the steps in the engineering design process to complete a team project; and effectively communicate design solutions to others. Standards in this course are aligned with Tennessee Common Core State Standards in English Language Arts & Literacy in Technical Subjects and Tennessee Common Core State Standards in Mathematics.*

Note: Students are expected to use engineering notebooks to document procedures, design ideas, and other notes for all projects throughout the course.

Program of Study Application

This is the second course in the *Engineering* program of study. For more information on the benefits and requirements of implementing this program in full, please visit the STEM website at http://www.tn.gov/education/cte/ScienceTechnologyEngineeringMathematics.shtml.

Course Standards

Safety

1) Accurately read and interpret safety rules, including but not limited to rules published by the National Science Teachers Association (NSTA), rules pertaining to electrical safety, Occupational Safety and Health Administration (OSHA) guidelines, and state and national code requirements. Be able to distinguish between the rules and explain why certain rules apply. (TN CCSS Reading 3, 4, 6)

2) Identify and explain the intended use of safety equipment available in the classroom. For example, demonstrate how to properly inspect, use, and maintain safe operating procedures with tools and equipment. (TN CCSS Reading 3, 4)

Career Exploration

3) In teams, use an online editing tool to develop an informational paper or infographic illustrating various engineering disciplines (e.g., civil, mechanical, electrical, chemical, biomedical, computer, agricultural, industrial, and aerospace). The descriptions should contain definitions, job roles, professional societies, and applicable licenses and/or certifications associated with each discipline. Use a variety of sources to gather data, cite each source, and briefly describe why the chosen source is reliable. (TN CCSS Reading 1, 7, 8; TN CCSS Writing 2, 6, 8)

4) Research the postsecondary institutions (colleges of applied technology, community colleges, and four-year universities) in Tennessee and other states that offer engineering or engineering technology programs. Write an informative paper or develop an infographic identifying

admissions criteria, the postsecondary programs of study, and the secondary courses that will prepare individuals to be successful in a postsecondary engineering or engineering technology program. (TN CCSS Reading 1, 5; TN CCSS Writing 4)

Engineering Design Process

5) Compare and contrast the following engineering design process with the following eight common practices of science and engineering (Achieve, 2013). Based on observations, write a brief paper explaining how the engineering design process and the practices overlap. Present findings to the class and refine the paper based on feedback. (TN CCSS Reading 2, 5; TN CCSS Writing 2, 5)

Engineering Design Process	Science and Engineering Practices
a) Identify the problem	a) Asking questions (for science) and defining problems (for engineering)
b) Identify criteria and specify constraints	b) Developing and using models
c) Brainstorm possible solutions	c) Planning and carrying out investigations
d) Research and generate ideas	d) Analyzing and interpreting data
e) Explore alternative solutions	e) Using mathematics and computational thinking
f) Select an approach	f) Constructing explanations (for science) and designing solutions (for engineering)
g) Write a design proposal	g) Engaging in argument from evidence
h) Develop a model or prototype	h) Obtaining, evaluating, and communicating information
i) Test and evaluate	
j) Refine and improve	
k) Create or make a product	
l) Communicate results	

Problem-Solving Format

6) Apply a problem-solving format for assigned engineering problems. The format should include the *problem statement* with illustration (e.g., free body diagram), what is *given,* what the student is asked to *find,* a list of assumptions, a list of equations to be used to solve the problem, and the step-by-step solution. (TN CCSS Reading 3; TN CCSS Writing 4)

Engineering Drawing**

7) Define the differences in technique among freehand sketching, manual drafting, and computer-aided drafting (CAD), and describe the skills required for each. Create a two-dimensional orthographic (multiview) drawing incorporating labels, notes, and dimensions, using sketching/geometric construction techniques. Apply basic dimensioning rules and properly use different types of lines (e.g., object, hidden, center). The orthographic projections should

include principle views of a simple object from top, front, and right sides. (TN CCSS Reading 3, 4, 5, 7; TN CCSS Writing 4; TN CCSS Math, G-MG)

8) Building on the knowledge of a two-dimensional drawing, create simple isometric (3-D pictorial) drawings, properly using lines (e.g., object, hidden, center), labels, and dimensioning techniques. (TN CCSS Reading 3, 4, 5, 7; TN CCSS Writing 4; TN CCSS Math, G-MG)

9) Use CAD software to create simple two-dimensional and three-dimensional drawings, accurately incorporating labels, notes, dimensioning, and line types to design drawings. Perform basic operations such as creating, saving files, opening files, storing files, and printing. (TN CCSS Reading 3, 4, 5, 7; TN CCSS Writing 4; TN CCSS Math, G-MG)

**Students who successfully completed Principles of Engineering and Technology *will already have foundational skills in Engineering Drawing, however these concepts should be reviewed. If students have not taken the* Principles *class, please cover these standards in full.*

Work, Force, Power & Machines

7) Drawing on relevant technical documents, define and identify at least one application for each of the six simple machines listed below. Describe each with sketches and proper notation in an engineering notebook.
    a. Inclined plane
    b. Wedge
    c. Lever
    d. Wheel and axle
    e. Pulley
    f. Screw

    In addition, define a combination of two or more simple machines working together as a compound machine, and identify at least one application of the compound machine. (TN CCSS Reading 1; TN CCSS Writing 2, 4, 7)

8) In teams, document the process of completing a simple project, such as building or using one or more simple machines. Participate in and describe each engineering design process step in an engineering notebook. Create a physical prototype or model based on the constraints specified in the project and the data gathered in the process of development. (TN CCSS Reading 3, TN CCSS Writing 2, 7)

9) Calculate force, work, and power, and apply these formulae to solve engineering problems as outlined by the instructor. Articulate specific scenarios in which an engineer must calculate force, work, and power. (TN CCSS Reading 3, 4, 5; TN CCSS Math N-Q)

10) Calculate the ideal mechanical advantage and actual mechanical advantage, and explain to classmates what this concept means in the context of engineering. Given a specified engineering problem, calculate the efficiency of a machine when the ideal mechanical advantage and actual mechanical advantage are known. (TN CCSS Reading 5; TN CCSS Math N-Q, A-SEE, A-CED, A-REI)

Mechanisms

11) Explain the definition of a mechanism. Interpret technical information in design problems to identify types of mechanisms such as:
    a. Linkages
    b. Cam and follower
    c. Bearings
    d. Gears
    e. Sprockets and chain
    f. Drives

    Explain the typical application and operation in systems of the components listed above, citing measurement and/or observed evidence to support explanations. (TN CCSS Reading 1, 4, 5; TN CCSS Writing 2)

12) Create equations that describe relationships to solve engineering problems using formulae such as gear ratio, speed ratio, torque, and torque ratio. For example, understand that if a gear ratio is 2, the input gear must make two complete revolutions to every one revolution that the output gear makes. (TN CCSS Reading 4, 5; TN CCSS Math A-CED)

Energy

13) Write an explanatory text defining energy, in particular its use in engineering, drawing on engineering texts and other technical documents. In addition, identify and explain the different forms of energy. The explanation should include the categorization of various forms of energy such as potential or kinetic. (TN CCSS Reading 2, 4, 5; TN CCSS Writing 2, 4)

14) Draw on engineering texts and other technical documents to synthesize and explain the concept of heat. Include definitions of the different temperature scales such as Fahrenheit, Celsius, and Kelvin. Furthermore, explain the three forms of heat transfer: conduction, convection, and radiation. (TN CCSS Reading 2, 4; TN CCSS Writing 2, 4, 8)

15) Understand and solve problems in specific engineering contexts involving conversion from one unit of energy such as British Thermal Units (Btu), Joule (J), and Calorie (cal) to another. Use this information to calculate the heat needed to change temperature. (TN CCSS Reading 3, 4, 5; TN CCSS Math N-Q)

16) Research print and electronic sources published by government, nonprofit, or engineering organizations to define different renewable energy sources such as biomass, hydroelectric power, geothermal, wind, and solar, as well as nonrenewable energy sources such as petroleum, natural gas, coal, and nuclear energy. In teams, create and deliver a presentation justifying the use of one energy source for their local community; the presentation must contain at least one summary table or graphic. In addition, the presentation should provide an analysis demonstrating the advantage of their selected source over others. (TN CCSS Reading 1, 2, 4, 7, 9; TN CCSS Writing 1, 4, 5, 7, 8, 9)

Electrical Systems

17) Write a technical report describing the subatomic particles (e.g., nucleus, proton, neutron, and electron) that make up an atom. Moreover, cite technical texts to explain how the particles relate to electricity, including characteristics that make materials either conductors or insulators, and explain the relationship between the flow of charge and electrical current at the subatomic and atomic level. (TN CCSS Reading 2, 4, 5; TN CCSS Writing 2, 9)

18) Write an explanatory paper defining, comparing, and contrasting voltage, current, and resistance, incorporating appropriate graphic illustrations (such as diagrams) to complement the narrative. Identify sources of voltage as well. For example, a battery is a source of voltage, and one end of the battery represents a positive charge, while the other end represents a negative charge. (TN CCSS Reading 4, 5, 7; TN CCSS Writing 2, 9; TN CCSS Math N-Q)

19) Calculate voltage, current, and/or resistance in a DC circuit using Ohm's law (V = IR). Explain how Ohm's Law relates voltage, current, and resistance, citing technical examples for illustration. For example, if voltage remains constant and resistance decreases, the current will increase. Given a physical circuit, demonstrate how to measure each using a digital multimeter. Where unexpected behavior is observed, cite specific evidence to explain the observations. Prepare an informative report comparing calculated values with measured values and include an explanation of any sources of error. (TN CCSS Reading 1, 4, 5, 9; TN CCSS Writing 2, 4, 7; TN CCSS Math N-Q)

20) Explain how series and parallel circuits function, including identification of their chief components, characteristics, and differences. Solve problems involving series and parallel circuits including calculating equivalent resistance and calculating voltage and/or current through elements within a circuit. (TN CCSS Reading 3, 4, 5; TN CCSS Writing 4; TN CCSS Math N-Q, A-SEE, A-CED)

Computer Software for Engineering Problem Solving

21) Use computer tools, such as spreadsheet software (e.g., Microsoft Excel), analytical/scientific software (e.g., MATLAB), and/or programming software (e.g., Microsoft Visual Basic) to solve at least one problem from the content described in the standards above. Examples may include the use of spreadsheets to input data from experimental tests and create graphs for presentation, or the use of MATLAB to solve a system of equations. (TN CCSS Reading 5, 7; TN CCSS Writing 9)

Team Project

22) As a team, identify a problem in the school or community. Draft a problem statement to guide a project incorporating engineering concepts from at least three of the content sections (i.e., electrical systems, energy, mechanisms, etc.) outlined above. Follow the engineering design process to solve the problem. Each team will develop a paper following the format of a typical technical report (see components of the report below). Upon completion of the report, create and deliver a presentation for a CTSO event using appropriate citation conventions. Refine the report as would a team of engineers by incorporating feedback from the presentation.

The written report should include, but is not limited to:

a) Background
b) Problem definition
c) Design constraints
d) Methodology
e) Data analysis (e.g., charts, graphs, calculations)
f) Results/Problem solution (including engineering drawings)
g) Conclusions and recommendations for future research.

(TN CCSS Reading 1, 3, 4, 5, 7, 9; TN CCSS Writing 2, 5, 6, 7, 8, 9)

Standards Alignment Notes

*References to other standards include:

- TN CCSS Reading: Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Reading Standards for Literacy in Science and Technical Subjects 6-12; Grades 9-10 Students (page 62).
    - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standard 10 at the conclusion of the course.
- TN CCSS Writing: Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects; Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12; Grades 9-10 Students (pages 64-66).
    - Note: While not directly aligned to one specific standard, students who are engaging in activities outlined above should be able to also demonstrate fluency in Standards 3 and 10 at the conclusion of the course.
- TN CCSS Math: Common Core State Standards for Mathematics; Math Standards for High School: Number and Quantity, Algebra, Functions, Geometry, Statistics and Probability.
    - Note: The standards in this course are not meant to teach mathematical concepts. However, the concepts referenced above may provide teachers with opportunities to collaborate with mathematics educators to design project-based activities or collaborate on lesson planning. While not aligned to one specific conceptual category, students who are engaging in the activities outlined above should be able to demonstrate quantitative, algebraic, functional, geometric, and statistical reasoning as applied to specific technical concepts. In addition, students will have the opportunity to practice the habits of mind as described in the eight Standards for Mathematical Practice.
- P21: Partnership for 21st Century Skills Framework for 21st Century Learning
    - Note: While not all standards are specifically aligned, teachers will find the framework helpful for setting expectations for student behavior in their classroom and practicing specific career readiness skills.
- Achieve: Next Generation Science Standards. (2013). “A Science Framework for K-12 Science Education.”